

Catapult Machine

Background

Humans have built machines for launching projectiles since ancient times. The Romans constructed *ballista* to hurl stones and *catapulta* to shoot arrows. In one design, stretched or twisted ropes were suddenly released to launch the projectile. Other machines bent and then released wooden beams. The medieval *trebuchet* harnessed the energy of a falling counterweight. More recently, catapults powered by compressed air provided the first effective method of launching aircraft from ships.



A medieval catapult

Challenge

In a small group, design, construct, test, and evaluate a catapult that launches a standard projectile to meet specified flight criteria. Your class as a whole will decide on the criteria for the flight and any restrictions on building materials and cost. Each catapult will be evaluated by comparing its performance to the expected results for an ideal projectile. As part of the project, you will prepare a report that outlines the design features of your catapult, provides an analysis of its operation, and makes recommendations for its improvement.

Materials

- construction materials, such as wood, plastic, cardboard, metal
- elastic materials, such as elastic bands, springs, or a mousetrap
- materials to attach parts together, such as fasteners, tape, and glue
- materials for the projectile
 - foam plastic egg carton
 - plastic sandwich bags
 - sand

Safety Precautions



- Wear eye protection when using power tools.
- Ensure that electrical equipment, such as power tools, is properly grounded.
- Take appropriate precautions when using electrical equipment.
- Take appropriate precautions when using knives, saws, and other sharp tools.
- Handle glue guns with care to avoid burns. Hot glue guns take several minutes to cool after they are disconnected.
- Wear eye protection at all times when testing your catapult.
- Test your catapult in a large, clear space, away from other people and from equipment and windows that could be damaged.
- Ensure that all spectators are behind the catapult before firing it.

Project Criteria

- A. As a class, decide on the criteria for evaluating your catapults. Possible challenges are to construct catapults that launch projectiles to hit a specific target, or to achieve maximum range or a specified flight time, or to reach a particular height or go over a wall.

- B. As a class, decide whether your catapults are to be made entirely from recycled materials or to be constructed from other materials within a set cost limit.
- C. Research, design, and construct your catapult to launch egg-carton projectiles. These projectiles are to be made from a single section of a foam plastic egg carton, filled with 25 grams of sand in a plastic bag. Tape the bag of sand securely inside the egg-carton section. The total mass of the projectile is not to exceed 30 grams.
- D. Prepare a written report about your project that includes
- an appropriate title and the identification of group members
 - a labelled design drawing of the catapult
 - an overview of the physics involved that includes calculations of
 - the average force applied to the projectile
 - the distance through which the force is applied
 - the time for which the force is applied
 - a theoretical prediction for the performance of your projectile that includes
 - its range
 - its maximum height
 - its flight time
 - an analysis of the catapult's performance that includes calculations or measurements of the
 - average launch velocity
 - launch angle
 - flight time
 - range
 - maximum height achieved
 - an evaluation of the catapult's performance and recommendations for its refinement

ASSESSMENT

After you complete this project

- **assess the performance of your catapult. How closely did the projectile meet your challenge criteria?**
- **assess the design of your catapult. What physics and engineering principles did you incorporate into its design?**
- **assess the problem-solving effectiveness of your group. What design and construction obstacles did you face during this project? How did you overcome them?**

Action Plan

1. Work in groups of two to four people.
2. Establish a time line for the design, construction, testing, and evaluation phases of this project.
3. Research possible designs and energy sources for your catapult. Select one that can be adapted to be feasible and meet the design criteria.
4. Construct and test your catapult, measuring the quantities specified above.
5. Prepare the written report and enter the competition.

Evaluate

1. Compare the average performance of your catapult with your theoretical predictions and the challenge criteria set out by the class.
2. Recommend refinements to your catapult. Indicate specifically how performance was affected by each design feature that you have identified for improvement.

WEB LINK

www.mcgrawhill.ca/links/physics12

For a lot of pictures and some stories about “leverage artillery” used in times past and for plans for various types of catapults, go to the above Internet site and click on **Web Links**.